March 1976

U S D A FOREST SERVICE
RESEARCH NOTE RM-313

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Locating Western Spruce Budworm Egg Masses with Ultraviolet Light

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Western spruce budworm egg masses on 24-inch (ca. 60 cm) Douglas-fir branches were located more quickly (48 percent faster) and accurately (22 percent more egg masses) with longwave ultraviolet light than with visible light. Most egg masses missed under ultraviolet light (89 percent) were old and parasitized, while almost half of those missed under visible light (42 percent) were new.

Keywords: *Choristoneura occidentalis, Pseudotsuga menziesii,* western spruce budworm detection.

Introduction

Western spruce budworm (*Choristoneura occidentalis* Freeman) infestations in the southern Rocky Mountains are classified, and defoliation predicted for the next year, on the basis of the number of new egg masses found on Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco) foliage (McKnight et al. 1970). Branches 24 inches (ca. 60 cm) long are collected from the midcrowns of codominant trees and examined in the laboratory. Needles on each branch are checked carefully in an attempt to find all egg masses. The examination process is time consuming and costly.

Jennings (1968) found that egg masses of the jack-pine budworm (*C. pinus pinus* Freeman) and the eastern spruce budworm (*C. fumiferana* (Clemens)) fluoresced when exposed to longwave ultraviolet light. Newly laid egg masses of the jack-pine budworm fluoresced more distinctly than old or parasitized ones.

During preliminary observations, both green and hatched western spruce budworm egg masses were also found to fluoresce under longwave ultraviolet light. Thus, a study was designed to compare: (1) the efficiency and accuracy of locating newly hatched western spruce budworm egg masses with longwave ultraviolet light and visible light, and (2) the characteristics of egg masses missed under each light source.

Methods and Materials

Field Collection

Midcrown Douglas-fir branches were collected from budworm-infested trees in the Sandia Mountains, near Albuquerque, New Mexico. A total of 80 branches, each with numerous new egg masses, was collected after egg hatch in early August 1975. Branches were cut from trees with a pole pruner. Each branch was pruned to approximately 24 inches (ca. 60 cm), and placed individually in a ¼-bushel (8.8-liter) paper sack. Ten sacks were then bundled together with heavy twine and kept out of direct sunlight while being transported to the laboratory for storage. Each bundle was stored in a walk-in cooler until the branches were examined under the different light sources.

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Laboratory Examination

Infested branches were examined within 2 weeks of collection by four college students. The students, two women and two men, had no previous experience checking foliage for budworm egg masses.

For the ultraviolet light examination, egg masses were counted in a darkened room under two GE 15-watt black-light lamps (F-15T8/BLB)[3] mounted in an 18-inch (ca. 46 cm) standard desk-type receptacle. The lamp was mounted about 1 foot (ca. 30 cm) above a worktable covered with black construction paper to minimize reflected light.

A battery-operated penlight was used to identify suspect objects, such as pitch droplets, spider egg cases, and bird droppings, which fluoresce under ultraviolet light and occasionally may resemble a budworm egg mass. However, the penlight was not used to search the foliage.

For the visible light examination, egg masses were counted in the same room with two 15-watt daylight lamps (F-15T8/D) mounted in each desk-type receptacle. The worktable was covered with white paper to provide contrast for the branches.

Measuring Efficiency

Each student examined 20 branches under each light source. Students 1 and 3 first used ultraviolet light and then, several days later, visible light. This sequence was reversed for students 2 and 4 to equalize experience. Separating the two examinations by several days reduced the ability of examiners to remember numbers of egg masses previously counted.

Initially, the maximum length and width of foliage on each branch were measured so that the foliated branch surface area examined by each student could be calculated (calculated by multiplying maximum length by maximum width and dividing by 2 (Mitchell 1974)). Then, each branch was clipped into small workable segments of 6 inches (ca. 15 cm) or less prior to examination. Any egg masses found were counted and left in place. Loose needles were also examined and placed in a box. These, together with all branch segments, were rebagged and returned to the cooler after each examination. The time required to examine foliage for egg masses was recorded for each branch.

Measuring Accuracy

Each student examined 10 heavily infested branches under each light source. Students 1 and 3 first used ultraviolet and then visible light, whereas students 2 and 4 reversed this order. As each branch was searched, all egg masses found were removed and stored in pill boxes labeled as to light source and sequence. The egg masses in each pill box were then examined, counted, and classified by the authors.

Characterizing Egg Masses

Egg masses found and removed under the second light source of each sequence were used to characterize those most likely to be missed under the first light source. Masses were examined with a stereomicroscope and classed as old or new, using criteria established by Buffam and Carolin (1966) and McKnight et al. (1970). Each class was then subdivided into normal or parasitized. Masses less than 50 percent parasitized were treated as normal. The number of egg masses for each class was recorded by light source.

Safety Considerations

The F-15T8/BLB black-light lamps used in this study emit longwave ultraviolet radiations ranging from 310–500 nanometers (nm), with a peak wavelength of 365 nm. Exposure to longwave ultraviolet radiations apparently does not cause skin damage.[4] Ultraviolet radiations below 320 nm cause skin reddening and sunburn, but these wavelengths amount to only 0.3 $\mu W/cm^2$ at 1 foot (ca. 30 cm) from a F-15T8/BLB lamp.[4] With two lamps at this distance, 7½ hours of continuous exposure would be required to develop a minimum perceptible reddening on previously untanned skin.[4] Any normally produced skin pigmentation, or pigmentation augmented by solar exposure, would provide enough skin protection to require a severalfold dosage increase before any noticeable reddening would develop. The students were exposed to the F-15T8/BLB lamps for a maximum of 6 hours during the study.

Results

Measuring Efficiency

The mean examination time required to locate egg masses (minutes per egg mass) on twenty

[3]*Trade and company names are used for the benefit of the reader, and do not imply endorsement or preferential treatment by the U.S. Department of Agriculture.*

[4]*Personal communication with I. Matelsky, Environmental Control Operation Manager, Light Research and Technical Services Operation, General Electric Company, Nela Park, Cleveland, Ohio.*

24-inch (ca. 60 cm) Douglas-fir branches, compared for each light source by analysis of variance was:

Student	Mean foliated surface area		Ultraviolet light	Visible light
	in²	*(cm²)*	*min/egg mass*	
1	190.6	(1229.7)	0.96	1.44
2	210.4	(1357.4)	1.03	2.52
3	179.9	(1160.6)	1.10	1.85
4	169.1	(1091.0)	1.52	3.21
Mean			1.15	2.26

The mean time required per egg mass for all examiners was significantly less ($P < .05$) under ultraviolet light (1.15 min) than visible light (2.26 min). Mean examination time per egg mass was 48 percent faster using ultraviolet light. The mean foliated surface area examined did not differ significantly ($P < .05$) among the students.

Measuring Accuracy

The proportion of egg masses found during the first examination was significantly higher ($P < .05$) under ultraviolet light:

Examination	Egg masses found under— Ultraviolet-visible	Visible-ultraviolet
	Number	
First	476	402
Second	28	151
Total	504	553

During the first examination, only 72.7 percent of the total egg masses present were found with visible light, compared to 94.4 percent with ultraviolet light.

Characterizing Egg Masses

Invariably, some egg masses were missed during the first examination, regardless of light source. Eighty-nine percent of the egg masses missed under ultraviolet light were classed as old or parasitized, whereas only 58 percent of those missed under visible light fell into these classes:

Egg mass class	Egg masses missed under— Ultraviolet	Visible
	Number	
New:		
Normal	3	64
Parasitized	0	0
Old:		
Normal	21	87
Parasitized	4	0
Total	28	151

Forty-two percent of the egg masses missed under visible light were new. These represented about 12 percent of the total egg masses actually present on the visible-light sample.

Conclusions

Searching small Douglas-fir branches for western spruce budworm egg masses took 48 percent less time per egg mass with longwave ultraviolet light than with visible light. Ultraviolet light also increased the number of egg masses found by 22 percent over visible light. Thus, ultraviolet light increased both the efficiency and accuracy of locating egg masses on Douglas-fir foliage.

Some egg masses were not located under either light source. The few missed under ultraviolet light were mostly old, parasitized masses, but almost half of those missed under visible light were new. The new egg masses missed under visible light constituted about 12 percent of the total egg masses present on the foliage. The failure to detect new egg masses with visible light should be recognized as a possible source of error in sampling procedures such as McKnight et al. (1970), which use new egg masses to predict defoliation the following year.

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CAUTION: Follow the manufacturer's recommendations when using ultraviolet light. Longwave (F-15T8/BLB) lamps emit a small amount of shortwave light, which is hazardous. These lamps pose no known safety hazard to workers with normal skin pigmentation. As a precaution, however, ordinary window glass can be taped beneath these lamps to screen out all shortwave light.